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(54) Title of the Invention: LATENT CRIMP DEVELOPABLE POLYESTER STAPLE FIBERS FOR WET-LAID NON-WOVEN FABRIC, AND METHOD OF MANUFACTURE

(57) Summary

Problems: To provide a latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric having a low basis weight and a good ability to pass through manufacturing processes.

Solution: A latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric, which fiber is a side-by-side or eccentric sheath-core fiber comprising a polyester A composed primarily of polypropylene terephthalate and a polyester B composed primarily of polyethylene terephthalate, wherein the weight ratio of polyester A to polyester B is from 30:70 to 70:30.

SPECIFICATION

Claims

1. A latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric, which fiber is a side-by-side or eccentric sheath-core fiber comprising a polyester A composed primarily of polypropylene terephthalate and a polyester B composed primarily of polyethylene terephthalate, wherein the weight ratio of polyester A to polyester B is from 30:70 to 70:30.
2. The latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric of claim 1, wherein the fibers have a cut length of 2 to 100 mm and a size of 0.5 to 6 deniers.
3. The latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric of claim 1 or 2 which satisfies the following conditions (1) and (2):

$$\mu(W) \leq 0.2 \qquad (1)$$

$$\mu(W)/\mu(D) \leq 0.7 \qquad (2),$$

wherein $\mu(W)$ is the yarn-to-yarn coefficient of friction when wet
$\mu(D)$ is the yarn-to-yarn coefficient of friction when dry.

4. A method of manufacturing latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric, the method being comprised of:
bicomponent spinning side-by-side or eccentric sheath-core filament comprising a polyester A composed primarily of polypropylene terephthalate and a polyester B composed primarily of polyethylene terephthalate, wherein the weight ratio of polyester A to polyester B is from 30:70 to 70:30, which spinning is carried out after melting the components at temperatures from 10 to 30°C higher than their respective melting points;
heat-treating the filament under tension in a drawing step at a treatment temperature of 100 to 190°C;
applying oil to the filament; and
cutting the filament to a length of 2 to 100 mm.

Detailed Description of the Invention

[0001]

Technical Field of the Invention:

The present invention relates to a polyester staple fiber for wet-laid nonwoven fabric, which fiber is endowed with latent crimp developability and is suitable for the production of shrinkable polyester nonwoven fabric having an excellent nonwoven fabric processing speed, a low basis weight and a good formation (fiber dispersion). The invention also relates to a method of manufacturing such fiber.

[0002]

Prior Art:

Polyester bicomponent staple fibers with latent crimp developability have hitherto been used in the production of stretchable polyester nonwoven fabric. Such fibers have

served as a constituent in various types of protective materials, including medical dressings that are required to have stretchability.

[0003]

However, prior-art polyester fibers having latent crimp developability, when used on dry-laid nonwoven fabric production lines, readily develop crimps (the term 'crimp' as used herein refers to resilient crimps) under stress applied in the axial direction of the fibers. This compromises uniform opening of the fibers on the cylinder in a card-type opening machine--a process which is generally carried out when the fibers have been rendered into a web, resulting in poor formation (fiber dispersion) in the card web when the opened web is scraped by the fly comb, so that only a low-quality nonwoven fabric can be obtained. Moreover, due to fiber damage from carding or needle punching, a stretchable nonwoven fabric that can utilize to full advantage the fiber properties is not always achieved. Attempts to employ production conditions which take this into account have only lowered the production efficiency. Moreover, when the fibers are rendered into nonwoven fabric, because the polymer itself has a low elastic recovery, only nonwoven fabric having a poor recovery from extension can be obtained.

[0004]

Problems to Be Resolved by the Invention:

The object of the invention is to provide polyester staple fibers having latent crimp developability for wet-laid nonwoven fabric, which fibers eliminate the above-described drawbacks associated with the prior-art production of stretchable nonwoven fabric, do not lower the non-woven fabric production line speed and, when rendered into nonwoven fabric, are suitable for the production of stretchable nonwoven fabric endowed with a high percent recovery from extension without lowering the nonwoven fabric production line speed.

[0005]

Means for Resolving the Problems:

To resolve the above problems, the invention provides the following.

(1) A latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric, which fiber is a side-by-side or eccentric sheath-core fiber comprising a polyester A composed primarily of polypropylene terephthalate and a polyester B composed primarily of polyethylene terephthalate, wherein the weight ratio of polyester A to polyester B is from 30:70 to 70:30.

(2) The latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric of (1) above, wherein the fibers have a cut length of 2 to 100 mm and a size of 0.5 to 6 deniers.

(3) The latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric of (1) or (2) above which satisfies the following conditions (1) and (2):

$$\mu(W) \leq 0.2 \qquad (1)$$

$$\mu(W)/\mu(D) \leq 0.7 \qquad (2),$$

wherein $\mu(W)$ is the yarn-to-yarn coefficient of friction when wet

$\mu(D)$ is the yarn-to-yarn coefficient of friction when dry.

(4) A method of manufacturing latent crimp-developable polyester staple fiber for wet-laid nonwoven fabric, the method being comprised of:
bicomponent spinning side-by-side or eccentric sheath-core filament comprising a polyester A composed primarily of polypropylene terephthalate and a polyester B composed primarily of polyethylene terephthalate, wherein the weight ratio of polyester A to polyester B is from 30:70 to 70:30, which spinning is carried out after melting the components at temperatures from 10 to 30°C higher than their respective melting points;
heat-treating the filament under tension in a drawing step at a treatment temperature of 100 to 190°C;
applying oil to the filament; and
cutting the filament to a length of 2 to 100 mm.

[0006]
Mode for Carrying Out the Invention:

The polypropylene terephthalate serving as a primary component of polyester A used in the invention is a polyester made up of a dicarboxylic acid component composed primarily of terephthalic acid and a glycol component composed primarily of trimethylene glycol, in which polyester the primary repeating units are trimethylene terephthalate units. Glycols such as ethylene glycol and butanediol, and dicarboxylic acids such as isophthalic acid and 2,6-naphthalenedicarboxylic acid may be copolymerized within a range that does not compromise the properties of polyester A. From the standpoint of mechanical properties, polyester A has an intrinsic viscosity of preferably at least 0.5, and most preferably at least 0.7.

[0007]

The polyethylene terephthalate serving as a primary component of polyester B used in the invention is a polyester made up of a glycol component composed primarily of ethylene glycol, in which polyester the primary repeating units are ethylene terephthalate units. Other components, including glycols such as butanediol and dicarboxylic acids such as isophthalic acid and 2,6-naphthalenedicarboxylic acid, may be copolymerized insofar as the balance with polyester A in thermal shrinkage and elastic recovery is not compromised.

[0008]

In the practice of the invention, polyester A and polyester B are combined in a ratio which, in the case of side-by-side type fibers, may be varied within a range centered on 50:50 that does not sacrifice the objects and advantages of the invention, the range being specifically from 30:70 to 70:30, and preferably from 40:60 to 60:40. In the case of eccentric sheath-core fibers, polyester A and polyester B are combined in a ratio which may be varied within a range centered on 50:50 that does not sacrifice the objects and advantages of the invention, the range being specifically from 30:70 to 70:30, and preferably from 40:60 to 60:40.

[0009]

For good fiber dispersibility in water and good nonwoven fabric strength, the cut length of the polyester staple fibers of the invention is preferably from 2 to 100 mm, and more preferably from 5 to 20 mm. To achieve a good hand in wet-laid nonwoven fabric, the fibers preferably have a size of from 0.5 to 6.0 denier. Fibers smaller than 0.5 denier in size tend to result in clumping when the fiber dispersion is mixed, whereas fibers larger than 6 deniers in size do not readily yield laid nonwoven fabric having a soft hand.

[0010]

When the yarn-to-yarn friction coefficient when wet $\mu(W)$ in the invention is greater than 0.2, the dispersibility of the polyester fibers in water worsens, making it necessary to add chemicals such as dispersants and thickeners during laying. This makes a uniform laid nonwoven fabric all the more difficult to achieve. Moreover, a ratio $\mu(W)/\mu(D)$ greater than 0.7 results in the generation of much fly in the polyester staple fiber production step, which tends to give rise to a variety of problems.

[0011]

Exemplary surface treatment agents for the polyester fiber of the present invention include polyalkylene glycols and/or derivatives thereof. Preferred polyalkylene glycols include polyethylene oxide, polypropylene oxide, poly(tetramethylene oxide) and any combinations thereof. Polyalkylene glycol derivatives include polyalkylene glycols on the ends of which have been polycondensed acid components. Illustrative examples of the acid components include terephthalic acid components, isophthalic acid components, benzenesulfonic acid alkali metal salt components, higher fatty acid components and monocarboxylic acid components.

[0012]

These surface treatment agents have an average molecular weight within a range of preferably 50,000 to 150,000, and more preferably 100,000 to 1,000,000. At an average molecular weight less than 50,000, the yarn-to-yarn friction coefficient when wet becomes large, resulting in poor dispersibility of the polyester fibers in water. On the other hand, at an average molecular weight above 150,000, the viscosity of the treatment agent itself becomes high, which tends to cause trouble such as fouling of the equipment and wraparound of the fibers onto rollers when the surface treatment agent is applied to the polyester filament.

[0013]

Pickup of the treatment agent by the polyester filament is preferably within a range of 0.1 to 2 wt %, and especially 0.2 to 1%. At a pickup of less than 0.1 wt %, dispersibility of the polyester fibers within water becomes poor. On the other hand, a pickup of more than 2 wt % fails to yield further improvement in the dispersibility, results in a waste of treatment agent, and tends to give rise to fouling during application of the agent to the polyester filament and undesirable wrapping of the filament onto rollers.

[0014]

The fiber preferably has a modified or hollow cross-sectional shape because when the fiber is rendered into a web, this imparts bulkiness, a good hand, and capabilities such as moisture transfer due to capillary action. Surface modifiers and additives for imparting antistatic properties, fire retardance, antimicrobial properties, odor prevention and a slick hand, as well as a third resin constituent, may be included insofar as the objects and advantages of the invention are achievable.

[0015]

The latent-crimpable polyester fibers for use in wet laying according to the present invention are bicomponent spun using a known polyester bicomponent spinning machine by melting the constituent polyester resins at a temperature 10 to 30°C higher than the respective melting points and causing them molten resins to converge just before the spinning orifices. The polyester A composed primarily of polypropylene terephthalate and the polyester B composed primarily of polyethylene terephthalate have intrinsic viscosities which, for the sake of safe polymer discharge from the spinning nozzles during melt spinning, are preferably set such that the melt viscosity difference therebetween when both are molten is not more than 500 poises at the same temperature, which is 10 to 30°C higher than the respective melting points. Moreover, cooling of the melt-spun yarn may be carried out by either uniform cooling or asymmetric cooling, provided this is done within a range that does not compromise the advantages of the invention. After cooling and haul off, the resulting undrawn filaments are submitted to a two-stage or three-stage drawing process. For example, the first drawing stage may consist of drawing the filaments at a tow temperature of 50 to 100°C and a machine draw ratio (MDR) of 0.70 to 0.7. The second stage may consist of drawing the filaments at an MDR of 0.80 to 0.85. If necessary to accommodate the intended use or application, a third drawing stage may be carried out in which drawing is carried out at an MDR of 0.9 to 0.95. Following drawing and the application of lubricant, the filaments are cut to a given cut length of 5 to 100 mm, although the filaments must first be heat-treated under tension at a heat treatment temperature of 100 to 190°C following the second or third drawing stage. The latent crimp developable polyester staple fibers for wet-laid nonwoven fabric of the present invention which are obtained by combining polyester A composed primarily of polypropylene terephthalate and polyester B composed primarily of polyethylene terephthalate have a high latent crimp developability. If heat treatment under tension is not carried out during drawing or heat treatment under tension is carried out at a temperature below 100°C, the degree of crimping by the latent crimps which develop during heat treatment becomes so large that this interferes with the interlocking between fibers which is desirable when the fibers are rendered into a nonwoven fabric, resulting in a nonwoven fabric of poor stretchability. Moreover, when heat treatment under tension is carried out at a temperature above 190°C, the latent crimp developability declines, resulting in a fiber web having poor recovery from extension.

[0016]
Examples

Examples are given below by way of illustration. The physical properties mentioned in the examples and the body of the specification were measured as described below.

(1) Intrinsic Viscosity:

Measured by a conventional method at 25°C and using p-chlorophenol as the solvent.

(2) Fiber Size:

Measured according to the method of JIS-1015-7-5.

(3) Yarn-to-Yarn Friction Coefficient When Dry and When Wet:

Filament samples were collected from the tow just prior to cutting. The yarn-to-yarn friction coefficient when dry was the value measured for polyester fiber dried at 100°C, and the yarn-to-yarn friction coefficient when wet was the value measured in water without drying. Measurement of the yarn-to-yarn friction coefficient was carried out by the Roder* technique described in JIS-L1015. When the fibers were wet, the procedure was modified so as to immerse in water the portion of the fiber being measured. The circumferential speed of the cylinder during measurement was set at 2 cm/min.

(4) Method for Evaluating Dispersibility:

Distilled water (50 cc) and 0.25 g of polyester fibers (actual weight) were placed in a 200 cc beaker, and stirred for 5 minutes using a magnetic stirrer. The mixture was then transferred to a 1000 cc measuring cylinder and diluted to 500 cc with distilled water, following which the measuring cylinder was capped and rotated once in the vertical direction to disperse the fibers. The dispersion state was evaluated by counting the number of united (non-dispersed) fibers contained within the mixture and determining the extent to which the fibers had spread within the water.

8: Excellent
O: Good
Δ: Fair
X: Poor

(5) Method for Producing Wet-Laid Nonwoven Fabric:

First, the staple fibers were dispersed in water to a slurry concentration of 0.15%. The water was then drained off, allowing the fibers to settle onto a sheet. The fibers were then entangled by water punching [sic]**, following which heat treatment was carried out at 160°C for 60 seconds, thereby giving a shrinkable nonwoven fabric having a basis weight of 30 g/m^2 and a thickness of 0.3 mm.

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* TN: Spelling is unconfirmed.
** TN: Possibly a reference to hydroentanglement.

(6) Basis Weight:

The test piece was cut into sections measuring 20×20 cm, held under standard conditions (temperature, 20±2°C; relative humidity, 65±2%) for at least 24 hours, and weighed on a balance. The basis weight was expressed as the weight per unit surface area (g/cm^2).

(7) Thickness:

The thickness of a sample was measured at 5 randomly chosen points with a Dial Gauge (compression plate diameter, 30 mm; 80 g) manufactured by Ozaki Co..

(8) Percent Recovery from 50% Extension:

A test specimen measuring 50×200 mm was mounted in a constant-rate-of-extension tensile testing machine equipped with an automatic data recorder at a clamping width of 100 mm in the line direction of the wet-laid nonwoven fabric. The specimen was pulled 50 mm at a pulling rate of 500 m/min, following which the pulling clamp was returned to its original position at the same rate. A load-elongation curve was drawn and, using the elongation (a) at the position to which the fabric returned following 50 mm extension, the percent recovery from 50% extension was calculated as follows:

$$\text{Percent recovery from 50\% extension} = ((50 - a)/50) \times 100$$

[0017]

Working Examples and Comparative Examples:

Using a bicomponent spinning machine, Polyester A (100% polypropylene terephthalate having an intrinsic viscosity of 0.83) and Polyester B (100% polyethylene terephthalate having an intrinsic viscosity of 0.63) were spun from a spinneret of round cross section at a nozzle temperature of 285°C. The constituent ratio (A:B) and fiber cross-sectional type in each case are shown in Table 1. The throughput per orifice was 1.07 g/min, and the spun filaments were wound up at a speed of 1,900 m/min to give undrawn yarn. The resulting undrawn yarn was subjected to a first drawing step at a draw ratio (MDR) of 0.75 in a warm 75°C bath. A second drawing step was then carried out at a draw ratio (MDR) of 0.80 under moist heating at 100°C with steam. Next, heat treatment under tension was carried out at 160°C, the surface treatment agent shown in Table 2 was applied, and the filaments were cut to a length of 10 mm with an Eastman cutter, thereby giving staple fibers according to the invention having a size of 2.5 deniers. A wet-laid nonwoven fabric was then produced by the method described earlier. Table 1 below shows the effects of the type of bicomponent fiber and the ratio between the fiber constituents, while Table 2 shows the effects of the fiber surface treatment agent used and the pickup of the agent by the fibers.

[0018]

Table 1

	Type of bicomponent fiber	Constituent ratio (A:B)	Percent recovery from extension of nonwoven fabric (%)
Working Example 1	side-by-side	50:50	76
Working Example 2	side-by-side	40:60	73
Working Example 3	side-by-side	30:70	70
Working Example 4	side-by-side	70:30	72
Comparative Example 1	side-by-side	20:80	59
Working Example 5	sheath-core	50:50	65

[0019]

Table 2*

	Surface treatment agent	Yarn-to-yarn friction coefficient			Number of united fibers	Dispersed state
		When dry	When wet	Wet/dry ratio	0	O
Working Example 6	Polyethylene oxide	0.40	0.19	0.41	0	8
Working Example 7	Polyethylene oxide	0.35	0.16	0.46	0	8
Working Example 8	Polyethylene oxide	0.33	0.17	0.52	0	8
Working Example 9	Polyethylene oxide	0.33	0.15	0.45	0	8
Working Example 10	Polyethylene oxide	0.30	0.14	0.47	0	8
Working Example 11	Polyethylene oxide	0.32	0.15	0.47	0	8
Working Example 12	Polyethylene oxide	0.30	0.15	0.50	0	8
Working Example 13	Polyethylene oxide	0.26	0.18	0.59	0	8
Comparative Example 2	Polyethylene oxide	0.32	0.23	0.72	2	Δ
Comparative Example 3	Polyethylene oxide	0.32	0.25	0.78	3	Δ
Comparative Example 4	Lauryl phosphate K salt	0.24	0.20	0.83	5	Δ
Comparative Example 5	Lauryl phosphate K salt	0.24	0.19	0.79	7	X
Comparative Example 6	POE alkyl ether	0.21	0.16	0.76	4	Δ

[0020]

Advantages of the Invention:

The fibers produced by the method of the invention have excellent dispersibility in the wet-laying process. Moreover, the development of latent crimp in the fibers when heat treated makes it possible to render the fibers into a stretchable nonwoven fabric having a low basis weight and excellent recovery from extension.

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* TN: Each of the two rightmost columns appears to have one too many entries.